

BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

Application of South Shore Energy, LLC and
Dairyland Power Cooperative for a Certificate of
Public Convenience and Necessity for the Nemadji
Trail Energy Center Combined-Cycle Project, to be
Located in the City of Superior, Douglas County,
Wisconsin

Docket No. 9698-CE-100

REBUTTAL TESTIMONY OF MICHAEL GOGGIN

1 **1. SUMMARY AND QUALIFICATIONS**

2 **Q: Please state your name and job title.**

3 **A:**Michael Goggin, and I am Vice President at Grid Strategies LLC, a consulting firm based
4 in the Washington, D.C., area.

5 **Q: For whom are you testifying?**

6 **A:**I am testifying on behalf of the Sierra Club.

7 **Q: Have you previously testified before the Wisconsin Public Service Commission**
8 **(“PSC”)?**

9 **A:**Yes, I offered testimony in the Badger Coulee case (Docket No. 05-CE-142) in 2014 and
10 the Cardinal-Hickory Creek case (5-CE-146) earlier this year. I have also testified before
11 state utility commissions in Illinois, Indiana, Minnesota, Missouri, Oklahoma, Virginia,
12 Iowa, Ohio, and Georgia.

13 **Q: What is your background and educational experience?**

14 **A:**I have worked on renewable energy integration issues for nearly 15 years. At Grid
15 Strategies I serve as an expert on that topic for a range of clean energy industry and

1 environmental advocate clients. For the preceding ten years I worked at the American
2 Wind Energy Association, where I provided technical analysis and advocacy regarding
3 renewable integration and other topics, including directing the organization's research
4 and analysis team from 2014-2018. Prior to that I worked at a firm serving as a consultant
5 to the U.S. Department of Energy, and at two environmental groups before that.

6 In the course of that work, I have co-authored nearly one hundred filings with the Federal
7 Energy Regulatory Commission; served as a technical reviewer for over a dozen national
8 laboratory reports, academic articles, and renewable integration studies; and published
9 academic articles and conference presentations on renewable integration, transmission,
10 and policy. I have an undergraduate degree with honors from Harvard University.

11 **Q: What is the purpose of your testimony?**

12 **A:** My testimony rebuts claims made on pages 3-8 of Witness Hamill's Direct Testimony in
13 support of her argument that "Because natural gas combined-cycle facilities are capable
14 of ramping up and down quickly, they are appropriate resources to accommodate greater
15 proliferation of intermittent resources."¹

16 **Q: Please summarize your testimony.**

17 **A:** First, I explain that changes in wind and solar output are gradual and predictable,
18 particularly given the Midcontinent Independent System Operator's ("MISO's) large
19 footprint and diverse fleet of resources. I then review analysis and operating experience
20 from MISO and others showing that larger amounts of wind and solar generation can be
21 reliably and efficiently integrated. Next, I point out that Witness Hamill significantly
22 overstates MISO's current renewable capacity and overestimates MISO's expected

¹ Hamill Direct Testimony, at pp. 7-8.

renewable levels. Finally, I explain that battery storage and other sources of flexibility available to MISO offer greater value for integrating renewable resources than gas combined cycle generators. Therefore, the need to accommodate greater proliferation of renewable generation does not justify adding a gas combined cycle generator.

2. REBUTTAL

Q. Witness Hamill discusses “large variations in both” wind and solar output, and states that “solar resources in particular commonly ramp up to, and down from, full production very quickly.”² Are these statements true for a fleet of wind or solar resources spread over a large area?

A: No. While the output of an individual wind or solar plant may ramp quickly due to passing weather conditions, the combined output of even a few wind³ or solar⁴ plants demonstrates only gradual changes. This is because the geographic diversity of the wind and solar plants prevents them from simultaneously being affected by the same change in the weather, significantly reducing the variability and uncertainty of their output. Across large regions such as the MISO footprint, changes in the fleetwide output of many wind and solar plants are gradual and predictable, even at very high renewable penetrations.⁵ In addition, wind and solar resources tend to exhibit complementary output profiles on both a daily and seasonal basis, so that one resource is often ramping up while the other is

² *Ibid.*, page 7

³ Holttinen et al., *Design and Operation of Power Systems with Large Amounts of Wind Power*, 2009, p. 25 <https://www.vtt.fi/inf/pdf/tiedotteet/2009/T2493.pdf>.

⁴ Mills, A., and Wiser, R., *Implications of Wide-Area Geographic Diversity for Short-term Variability of Solar Power*, September 2010, <https://pdfs.semanticscholar.org/dca9/d2df3e01a27678599257a47bdc6d5228684f.pdf>.

⁵ Vibrant Clean Energy, *MISO High Penetration Renewable Energy Study for 2050*, January 2016, https://www.vibrantcleanenergy.com/wp-content/uploads/2016/05/VCE_MISO_Study_Report_04252016.pdf.

1 ramping down.

2 The National Renewable Energy Laboratory recently found that even with wind and solar
3 providing 30% of the electricity in the Eastern U.S., the increased need for frequency
4 regulation reserves in both MISO and the rest of the Eastern Interconnection would be
5 modest. In fact, Eastern Interconnect frequency regulation reserve needs would increase
6 by less than 20 TWh; for comparison, the Eastern Interconnect requires 97 TWh of
7 contingency operating reserves to accommodate the abrupt failures of large conventional
8 generators.⁶ Thus, conventional generator outages have a 5 times larger impact on
9 operating reserves needs than increasing renewable output to 30% of generation.

10 Ongoing analysis by MISO indicates that significant renewable integration issues only
11 begin to emerge as renewable capacity levels reach 30% to 40% of system installed
12 capacity,⁷ which is several times greater than current levels. The 2014 Minnesota
13 Renewable Energy Integration and Transmission Study similarly found that Minnesota
14 could reliably obtain 40% of its electricity from renewables, with MISO-wide renewable
15 levels at 15%.⁸ Studies in other regions have found that renewable energy levels of 24-
16 50% can be reliably accommodated.⁹ For comparison, wind and solar accounted for
17 about 8% of generation in MISO in 2018.¹⁰

⁶ Bloom et al., *Eastern Renewable Generation Integration Study*, August 2016, pp. 63-65, Table 31, <https://www.nrel.gov/docs/fy16osti/64472.pdf>.

⁷ MISO, “Renewable Integration Impact Assessment,” July 17, 2019, p.5, <https://cdn.misoenergy.org/MISO%20Dynamics%20WebEx364646.pdf>.

⁸ Minnesota Department of Commerce, “Minnesota Renewable Energy Integration & Transmission Study,” Accessed October 15, 2019, <https://mn.gov/commerce/industries/energy/distributed-energy/mrits.jsp>.

⁹ Ahlstrom et al., *Relevant Studies for NERC’s Analysis of EPA’s Clean Power Plan 111(d) Compliance*, June 2015, <https://www.nrel.gov/docs/fy15osti/63979.pdf>.

¹⁰ Patton, D. B., “Summary of 2018 MISO State of the Market Report,” June 26, 2019, p. 11,

1 Real-world experience demonstrates that much higher levels of renewable energy can be
2 integrated in MISO without reliability concerns. Last year the Southwest Power Pool
3 obtained more than 25% of its electricity from wind,¹¹ while the Public Service Company
4 of Colorado has similarly high levels of renewables. Both grid operators expect to see
5 continued growth in renewables. Power systems in other countries, like Ireland, Spain,
6 Portugal, Germany, and Denmark, have reliably accommodated even higher levels of
7 renewables.¹²

8 **Q: When assessing the impact of renewable generation on power system variability and**
9 **flexibility needs, what is the relevant geographic area?**

10 **A:** In general, variability must be managed at the MISO-wide level, reflecting that MISO is
11 the North American Electric Reliability Corporation (NERC) Balancing Authority and
12 can generally use resources across the entire MISO footprint to balance electricity supply
13 and demand. The renewable-heavy zones in MISO North are well connected with the rest
14 of MISO, which allows them to import and export power with the rest of MISO to deal
15 with zonal fluctuations in supply and demand. MISO data confirm that Zones 1-3, which
16 contain the primary wind-producing areas in MISO North, have very large Capacity
17 Import Limits and Capacity Export Limits.¹³ Moreover, these are the import and export

https://www.potomaceconomics.com/wp-content/uploads/2019/06/2018-SOM-Presentation_to-BOD_Final2.pdf.

¹¹ Southwest Power Pool, *State of the Market 2018*, May 15, 2019, p. 45,
<https://www.spp.org/documents/59861/2018%20annual%20state%20of%20the%20market%20report.pdf>.

¹² U.S. Department of Energy, *2018 Wind Technologies Market Report*, August 2019, p. 6,
<https://www.energy.gov/sites/prod/files/2019/08/f65/2018%20Wind%20Technologies%20Market%20Report%20FINAL.pdf>.

¹³ MISO, “2018/2019 Planning Resource Auction Results,” April 13, 2018,
<https://cdn.misoenergy.org/2018-19%20PRA%20Results173180.pdf>.

1 limits during peak demand periods; import and export transmission capacity tends to be
2 significantly greater during the lower-demand hours when renewable output and
3 renewable variability tend to be at their highest. Because MISO can accommodate
4 renewable variability and uncertainty in MISO North by importing and exporting large
5 amounts of power with the rest of MISO, it is not appropriate to focus on MISO North in
6 assessing renewable integration concerns.

7 Even MISO as a whole has significant ability to import and export power with
8 neighboring power systems to net out fluctuations in supply and demand, with hourly
9 imports typically totaling thousands of MWs and exceeding 10,000 MW or more during
10 time periods when needed.¹⁴ Moreover, NERC rules permit MISO to run supply and
11 demand imbalances for up to 30 minutes,¹⁵ which reflects the fact that the stability of
12 power system frequency is determined by the balance of electricity supply and demand
13 across the Eastern Interconnection that covers the entire Eastern U.S. and much of
14 Eastern Canada. As a result, MISO can use imports and exports from and to neighboring
15 power systems to accommodate any renewable integration issues.

16 Utilities banded together into large power pools and physical interconnections primarily
17 because of the benefits large aggregations of electricity supply and demand provide for
18 dealing with all sources of variability. Large grid operating areas like MISO are well
19 equipped to accommodate high levels of renewable energy use as the diversity of
20 resources across the footprint nets out most fluctuations in supply and demand, reducing

¹⁴ MISO, “Historical Real-time Net Scheduled Interface,” 2019,
https://docs.misoenergy.org/marketreports/2019_sr_hist_is.csv, (see, for example, imports in
excess of 10,000 MW from PJM, SPP, and IESO midday on January 30, 2019)

¹⁵ NERC, *Standard BAL-001-2-Real Power Balancing Control Performance*, p. 1,
<https://www.nerc.com/files/BAL-001-2.pdf>.

1 the burden on all utility members.¹⁶ For example, when MISO had 12 GW of wind
2 capacity in 2014, it noted that the impact of wind output variability on its need for fast-
3 acting operating reserves like frequency regulation is “little to none.”¹⁷

4 **Q: Witness Hamill projects that wind and solar will achieve large penetrations in**
5 **MISO North in the near future. She states that there are already 25,900 MW of**
6 **wind capacity operating in the MISO North states. Is that accurate?**

7 **A:** No. MISO’s most recent corporate fact sheet, dated June 2019, reports that 19,086 MW
8 of wind capacity are currently operating in all of MISO, and that there are 20,447 MW of
9 “registered” wind capacity.¹⁸ Other reports indicate MISO is on track to add about 1.5
10 GW of wind capacity in 2019,¹⁹ so in 2020 wind capacity levels for all of MISO will still
11 be more than 5 GW short of the level claimed by Witness Hamill for MISO North alone.
12 It is possible that Witness Hamill’s total incorrectly includes wind capacity operating in
13 the PJM portion of Illinois and the SPP portion of Missouri.

14 **Q: Witness Hamill’s estimates for future renewable capacity are also based on the**
15 **assumption that 21 percent of wind and solar projects in the Definitive Planning**
16 **Phase of the MISO interconnection queue are completed. Is 21 percent a reasonable**

¹⁶ Milligan, M., Kirby, B., Gramlich, R., and Goggin, M., *Impact of Electric Industry Structure on High Wind Penetration Potential*, June 2009, p. 23, <https://www.nrel.gov/docs/fy09osti/46273.pdf>.

¹⁷ Navid, N., “Multi-faceted Solution for Managing Flexibility with High Penetration Renewable Resources,” June 2013, p. 4, <https://www.ferc.gov/CalendarFiles/20140411130433-T1-A%20-%20Navid.pdf>.

¹⁸ MISO, “Corporate Fact Sheet,” June 2019, <https://cdn.misoenergy.org/corp%20fact%20sheet%206-27-2019360294.pdf>.

¹⁹ Watson, M., “MISO to Add 4 GW of Capacity in 2019, About half Natural Gas, Half Renewables,” August 27, 2019. <https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/082719-miso-to-add-4-gw-of-capacity-in-2019-about-half-natural-gas-half-renewables>.

1 **estimate for the success rate for wind and solar projects at that stage in the**
2 **interconnection queue?**

3 **A.** No. While that may be the historical average success rate, queue success rates have
4 decreased dramatically in recent years. For example, only 7% of the wind capacity that
5 entered the Feb 2017 Definitive Planning Phase for the West zone are still in the queue,
6 while the other 93% have withdrawn. Specifically, 27 projects with a capacity of 3,421
7 MW applied in February 2017, and now only 2 projects comprising 250 MW remain in
8 the interconnection queue.²⁰

9 **Q. Why?**

10 **A.** Transmission constraints greatly limit the amount of new renewable resources that can
11 connect. MISO's map of available transmission capacity shows that most of the wind
12 resource areas in Minnesota, North Dakota, and South Dakota have between negative
13 5,000 MW and negative 10,000 MW of available transfer capacity, while most of
14 Wisconsin has between negative 1,000 MW and negative 5,000 MW of available transfer
15 capacity.²¹ In other words, the available transmission capacity in the primary wind-
16 producing areas of MISO is already more than fully subscribed.

17 **Q: Are the transmission constraints holding back renewable development being solved?**

18 **A:** No. No major transmission projects to integrate renewables have been planned in MISO
19 since the Multi Value Projects were announced in 2011. As shown in the MISO map
20 cited above, the additional transmission capacity provided by those projects has already
21 been mostly if not entirely subscribed. For example, the Public Service Commission of

²⁰ MISO, "MISO Queue Project Information at DPP Decision Points as of 08/12/2019"
(available upon request)

²¹ MISO contour map available at https://cdn.misoenergy.org/GI-Contour_Map108143.pdf.

1 Wisconsin recently approved the Cardinal-Hickory Creek transmission project, which is
2 critical for delivering renewable energy. However, renewable projects that are already
3 planned, and that in some cases are already operating, will fully subscribe the additional
4 capacity provided by that line. Unfortunately, building new transmission can take a
5 decade or more, as demonstrated by the fact that many Multi Value Projects that were
6 planned nearly a decade ago are still under construction or have not yet begun
7 construction.²²

8 **Q: As a result, are Witness Hamill’s concerns about integrating large amounts of**
9 **renewable energy in the near future credible?**

10 **A:** No, in part because Witness Hamill greatly overstates existing renewable capacity in
11 MISO North and then assumes aggressive levels of renewable deployment that will be
12 difficult to achieve without significant changes to MISO’s transmission planning process.
13 Regardless, as I noted earlier, multiple studies have shown that MISO can reliably
14 accommodate renewable penetrations in excess of 30%, many times greater than current
15 levels.

16 **Q: Is the baseload/intermediate/peaking framework presented on page 3 of Witness**
17 **Hamill’s testimony relevant for today’s power system?**

18 **A:** No, it is largely obsolete. Baseload primarily referred to resources like coal or nuclear
19 that produced low-cost energy, and therefore were designed to operate a large share of
20 the time. However, renewable resources can now produce lower-cost energy than coal or
21 nuclear generators. As a result, a better framework is to assess which portfolios of

²² MISO, “Regionally Cost Allocated Project Reporting Analysis,” July 2019,
<https://cdn.misoenergy.org/MVP%20Dashboard117055.pdf>.

resources provide the power system with the energy, flexibility, and peak capacity it needs at the lowest cost.

Q: Turning to the proposed natural gas plant, are “natural gas combined-cycle facilities... capable of ramping up and down quickly,” as Witness Hamill claims on page 7?

A: Relative to other potential sources of flexibility, no. As Witness Hamill outlines, the proposed gas combined cycle generator is comprised of an H-class frame gas turbine generator, a heat recovery steam generator, and a steam turbine. The plant’s two steam generators typically cannot be quickly turned on or off or operated with a high degree of flexibility, due to the inherent physical limits of the steam boiler and other components. The frame gas turbine can be operated without the steam generators, though this significantly reduces the efficiency of the power plant. Moreover, frame gas turbines tend to be less flexible than other types of gas generators, like aeroderivative gas turbines and reciprocating engines.²³

Q: Are there other options for increasing power system flexibility?

A: Yes. NREL has created a “flexibility supply curve” to illustrate the roughly two dozen potential sources of power system flexibility.²⁴ This includes batteries and other forms of energy storage, transmission expansion, controllable sources of electricity demand, and reforms to grid operations and markets. There are many potential sources of flexibility,

²³ Gonzalez-Salazar, M.A., Kirsten, T., and Prehlik, L., “Review of the Operational Flexibility and Emissions of Gas-and Coal-fired Power Plants in a Future with Growing Renewables,” Renewable and Sustainable Energy Reviews, Volume 82, Part 1, February 2018, pp. 1497-1513, <https://www.sciencedirect.com/science/article/pii/S1364032117309206>.

²⁴ Cochran et al., “Flexibility in 21st Century Power Systems,” May 2014, p. 11, <https://www.nrel.gov/docs/fy14osti/61721.pdf>.

1 and many of them are likely to be more economic and provide greater flexibility than a
2 gas combined cycle generator.

3 **Q: How does the flexibility of combined cycle gas generation compare to that of battery**
4 **storage?**

5 **A:** Battery storage resources can typically be dispatched from full charging to full
6 discharging and back again within a fraction of a second, and have no minimum down
7 time between cycles. Most combined-cycle plants would take many hours to ramp from
8 zero to full output and back to zero, and would incur significant wear and tear from
9 cycling in that fashion.²⁵ In addition, only storage resources have the ability to absorb
10 excess generation by charging. Unlike the proposed gas generator, battery storage
11 resources can be added almost anywhere on the power system, including in renewable-
12 producing areas. Storage located on the renewable-generator side of transmission
13 constraints can provide the added advantage of capturing wind or solar generation that
14 would have been curtailed and storing it until the transmission congestion has alleviated.
15 In fact, many renewable developers are proposing to co-locate batteries at solar and wind
16 plants.

17 **Q: What is the contribution of battery storage resources to meeting peak demand**
18 **needs?**

19 **A:** Recent analysis for the PJM power system shows that at current and foreseeable
20 penetrations of storage resources, a battery's contribution to meeting peak demand needs

²⁵ Gonzalez-Salazar, M.A., Kirsten, T., and Prchlik, L.,
<https://www.sciencedirect.com/science/article/pii/S1364032117309206>.

1 is effectively 100% of the battery's nameplate capacity.²⁶

2 **Q: Is this statement from Witness Hamill's testimony correct? "In the future, storage**
3 **devices may help accommodate intermittent resources, but it is unclear at this point**
4 **when and to what extent storage will proliferate."**

5 **A:** No, battery resources are already proliferating. The MISO interconnection queue contains
6 nearly 2,700 MW of proposed battery resources.²⁷ Utilities have recently announced
7 large-scale battery procurements totaling multiple GW,²⁸ recognizing the value of storage
8 for meeting multiple power system needs, and these procurements are poised to grow as
9 the economics of batteries continue to improve.²⁹

10 **Q: Therefore, do you think a combined cycle gas generator is needed to integrate**
11 **renewables in MISO North?**

12 **A:** No. If anything, investing in a resource like that will only harm renewables by precluding
13 the development of more flexible resources like battery storage in the near future.

14 **Q: Does this conclude your Rebuttal testimony?**

15 **A:** Yes.

²⁶ Carden, K., Wintermantel, N., and Krasny, A., *Capacity Value of Energy Storage in PJM*, July 2019, <http://www.astrape.com/?ddownload=9124>.

²⁷ MISO, "Generator Interconnection Queue," https://www.misoenergy.org/planning/generator-interconnection/GI_Queue/.

²⁸ For example, see Deign, J., "Xcel Attracts 'Unprecedented' Low Prices for Solar and Wind Paired with Storage," January 8, 2019, <https://www.greentechmedia.com/articles/read/record-low-solar-plus-storage-price-in-xcel-solicitation>; Morehouse, C., "FPL Unveils Plans for Largest Solar-powered Battery in the World," March 28, 2019, <https://www.utilitydive.com/news/fpl-unveils-plans-for-largest-solar-powered-battery-in-the-world/551544/>.

²⁹ Wood Mackenzie, *U.S. Energy Storage Monitor*, 2019, <https://www.woodmac.com/research/products/power-and-renewables/us-energy-storage-monitor/>.